How Strong is Demand for Public Transport Service in Nepal? A Case Study of Kathmandu Using a Choice-Based Conjoint Experiment

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Abstract

A public transport system is the most efficient and equitable solution to the challenges of urban mobility and climate change. To improve public transport, technological innovations, policy interventions, and behavioral changes should all be applied appropriately; however, there is a lack of information about the demand for public transport services in developing countries. This paper aims to measure the degree of demand for public transport services by comparing various factors using as a case study Kathmandu, one of the most congested urban areas in a developing country. We designed a choice-based conjoint experiment with five attributes: mode of transport, waiting time, one-way fare per km, commute time per km, and payment method.

Our results indicate that 73% of the respondents are in favor of changing the current transport policy and wish for a shift to public transport, which means that most commuters are in favor of the proposed mode of transport, that is, MRT. On the other hand, the study reveals that respondents have a negative evaluation of motorbikes, one of the most popular modes of transport in Kathmandu. Our results provide transport planners guidance for addressing current public transport policies.

1. Introduction

Kathmandu Valley belongs to Bagmati Province and extends into three administrative districts of Nepal, namely, Kathmandu, Bhaktapur, and Lalitpur, with a total area of 899 sq km *(*Fig. 1*)*. The three districts have two metropolitan areas, the metropolitan city of Kathmandu and the metropolitan city of Lalitpur, and sixteen municipalities. Kathmandu is the capital of the Federal Democratic Republic of Nepal and is the country's most important political, administrative, educational, cultural, and commercial center. In the 2011 census year, the total population of the Kathmandu Valley was 2,517,023, with an annual growth rate of 4.63%. This represents 9.32% of the country's total population, in just 0.49% of the country's area. The Central Bureau of Statistics of Nepal predicts that the population of the Kathmandu Valley will reach four million by 2035 (CBS, 2018, JICA, 2017).

The road transport system provides the main mode of mobility in Nepal. Rapid urbanization and increasing economic activities in cities have dramatically increased the demand for vehicles in urban areas. Due to ineffective public transport services, people are attracted to private vehicles, and the number of private vehicles is increasing rapidly compared to that of public vehicles. In the last 15 years, the number of motorbikes and low occupancy modes of public transport, that is, minibuses and microbuses, have increased rapidly. Although the government has invested in the expansion of roads in the city of Kathmandu, the increasing number of private vehicles means that the traffic situation remains unchanged. This shows that expanding the road alone is not a sustainable solution for improving public transport. Considering the geographic area and the distance of the city from business and official areas, it is necessary to offer reliable public transport and nonmotorized transport even in cities such as Kathmandu. The Kathmandu Valley is completely dominated by motorbikes, which constitute 79.1% of the total fleet, followed by private vehicles (cars, vans, and jeeps) at 12.42%, heavy-duty vehicles at 4%, and public transport vehicles at 2.67%, and others, with an overall annual growth rate of 14% (DOTM, 2019). The share of low-occupancy vehicles, that is, minibuses and microbuses, represents 94% of all public transport vehicles, and large buses make up only 6% (JICA, 2017). For the past decade, the road transport service in the Kathmandu Valley has been affected by insufficient road length, narrow and busy roads, unattended traffic, poor traffic management infrastructure, a mix of old and new vehicles, and a multimodal

public transport system. The quality of service of the current public transport system in Kathmandu is poor, and public transport involves more travel time than private modes of travel. A mass rapid transit (MRT) system should be implemented to reduce congestion, decrease fossil energy consumption, and decrease air pollution (Dhakal, 2006, JICA, 2017, KSUTP, 2017, MoUD, 2017 and IBN, 2017, Bajracharya and Shrestha, 2017 & ICIMOD, 2017). The current public transport system in the Kathmandu Valley is complex, and the quality of service is poor (World Bank, 2019).

Transport is the most important social and environmental issue in the world (Kingham et al., 2001). Transport is the infrastructure of infrastructures (Acharya and Pokharel, 2015) and is considered fundamental for urban development. The government of Nepal has prioritized the development of the transport sector. The main objective of the "National Transport Policy is to develop a reliable, cost-effective, safe, facility oriented and sustainable transport system that promotes and sustains the economic, social, cultural and tourism development of Nepal as a whole" (National Transport Policy 2001). Chen and Chai (2011), using the theory of planned behavior, the technology acceptance model, and the concept of habit, studied the intentions of commuters to switch to public transit in Kaohsiung City, Taiwan, and found that the habitual behavior of private vehicle users obstructs a commuter scheme to switch from private vehicles to public transit. JICA (2017) recommended the appropriate timing for the commencement of MRT system operation in Kathmandu, based on the introduction of mass transit systems in 24 Asian mega-cities and related to the gross income and population of the city. In each of these cases, the first MRT operation was launched when the respective city's gross product was $3 to $30 billion. In the Kathmandu Valley, the population is projected to be four million, and per capita GDP will exceed US$ 900 by 2030. Thus, "based on experience in other Asian megacities, it shall be appropriate to introduce the 1st MRT system in the Kathmandu Valley between 2020 and 2030" (JICA 2017, p. 122). Shrestha et al. (2013) found that increasing vehicle speeds would reduce vehicle emissions, and that increasing urban mobility would improve the overall quality of life in the Kathmandu Valley. Das et al. (2018) stated that technological change may play an important role in minimizing vehicular air pollution in Kathmandu. Ashalatha, Manju, and Zacharia (2013), applying multinomial logistics (MNL), found various factors affecting particular modes of transport. In a case study in the city of Thiruvananthapuram, India, the main reason for shifting from buses to two-wheelers or cars was that bus transport service was inefficient and unreliable. Jain, Aggarwal, Kumar, Singhal & Sharma (2014) identified reliability, comfort, safety, and cost as the main criteria for the modal shift from private vehicles to public transport, with Delhi as a case study. Using the pairwise weighing method (analytical hierarchy process), they found that safety was the most important criterion (36%), followed by reliability (27%), cost (21%), and comfort (16%). Liu and Guo (2015) studied the utility and weight of factors related to bus transit service quality in Nanjing, China, by applying conjoint analysis.

The private sector is responsible for almost 99% of the investment in public transport services in Nepal. There is no integrated policy for the management of public transport services. Government regulations and monitoring capacities are weak. Along with reducing the attraction of private vehicles, encouraging Non-motorized Transportation and the use of public transport is an urgent agenda item for sustainable urban mobility. For the effective implementation of such an intervention, it is best to know users' preferences. This study examines the main attributes affecting commuters in the modal shift to public transport service in Kathmandu. Mass transit systems help to connect communities, support local economies, and improve the living standards of disadvantaged individuals. Therefore, a wide range of studies have been conducted in the field of public transport around the world. Researchers are constantly studying ways to improve public transport. They have

focused mainly on the infrastructure sector, the behavioral sector, and the psychological sector. The current study was designed to understand the preferences of Kathmandu Valley commuters regarding the modern transport system before implementing future public transport policy, through a case study that provided a unique opportunity to investigate people's perceptions of potential new services and their willingness to implement them.

The main objective of the choice-based conjoint experiment in this research is to examine the attributes affecting the choices and behaviors of commuters for improved public transport services in Kathmandu by answering the following questions: What factors are associated with commuters' adoption of an improved public transport service?; Which attributes of the public transport service cause a modal shift?; How does each attribute affect the probability of various preferences?; What is the interaction with the passenger and the causal effect of the attribute?

To answer these questions, we have generated attributes of hypothetical improved public transport services that have numerous external impacts on the surrounding environment.

2. Methodology

This experiment was carried out in Kathmandu, Nepal, where the main mode of mobility is road transport. Over the past decade, Kathmandu Valley has experienced rapid urbanization, high population growth, uncontrolled urban sprawl, and increased motorization, leading to problems with congestion, vehicular conflict, traffic accidents, environmental degradation, and poor public transport services. The government of Nepal plans to carry out various projects to improve the existing system. This study helps us to understand the preferences of commuters for improving public transport services in a very densely populated area.

For our study, the data were collected in two phases: the pilot survey and the main survey. The surveys were carried out within the periphery of the Ring Road, which is 27.3 km in length. For the purposes of the study, we deliberately chose a list of 71 main stops and divided the city into four study areas by central main stop and then separated the list of 71 stops into the four zones. The main survey lasted nine days and used the paper-based street survey method. For the everyday survey, the author prepared a random list of stops/streets in a randomly selected area using the Excel randomization function, from the selected list of stops with that value that connect to the Ring Road area *(*Fig. 1*).*

The Ring Road area was purposively selected based on four criteria: (1) it covers the central area of the city of Kathmandu; (2) it has connections to the Lalitpur and Bhaktapur districts; (3) it has a high population density; and (4) almost every commuter in Kathmandu Valley must use the Ring Road to get around the city. During the survey, we approached 400 commuters, and 373 commuters participated in our survey, for a response rate of 93.25%.

Conjoint analysis is used to study how buyers appreciate the characteristics of products or services and to predict buyer behavior (preference). It can be used to estimate the psychological trade-offs that commuters make when evaluating different attributes together. In this study, a randomized conjoint experiment was used to obtain the stated preferences of the respondents. In a conjoint experiment, the respondent evaluates profiles based on their attributes and levels, and then either chooses the option that gives them the highest utility or ranks the options. It is assumed that the respondent determines the overall utility by adding the utility provided

by each attribute level. Through this experiment, we can determine the influence of each attribute level on the respondent's choice (Hainmueller, Hopkins, Yamamoto, 2014). While experimenting, we developed survey questionnaires with four parts: (1) information, (2) scenario, (3) choice-set of the randomized conjoint experiment, and (4) background information about the respondent, including age, sex, marital status, level of education, occupation, regional location, employment status, monthly income, average monthly cost of commuting, vehicle ownership, main mode(s) of transport, typical usage time, and household members.

As suggested by Klojgaard, Bech, and Sogaard (2012), the attributes and levels relevant for a conjoint analysis of the public transport system were identified through quantitative methods. First, a literature search was conducted to identify the relevant attributes of public transport service from the commuters' perspective. Second, a pilot survey was conducted among 28 commuters from different areas of Kathmandu City using a virtual interviewing method. In this study, the randomized conjoint experiment consisted of five attributes, each with two to five different levels. The attributes and levels of each choice profile were assigned randomly. Details of the attributes, levels, and baseline are shown in the table below.

After reading the scenario, respondents were asked to consider three sets of choices – choice set (A), choice set (B), and choice set (C) – and then rank these 1, 2, and 3 based on their preference for enhanced public transport services. Each profile was designed with different alternatives.

In this study, we tried to identify commuters' preferences for hypothetically improved public transport policies by estimating the probability of internal choice and external choice. Regarding internal probability, we estimated respondents' preference under two hypothetical alternative policies: choice (A) and choice (B). For external choice probability, we estimated respondents' preference between the status quo and two alternative hypothetical policies. Each profile had three alternatives; from the left, the first two were hypothetical alternatives with five attributes and levels, and the third alternative was the status quo. These attributes were randomized for each respondent to avoid any possibility of an ordering effect. Similarly, to avoid cognitive strain, the order was randomized for all three profiles given to the same respondent. To estimate the probability of internal and external choice, we followed the approach suggested by Hainmueller et al. (2014). These authors nonparametrically identified the average marginal component effect (AMCE) for each of the attributes and levels based on the probability of choosing a profile by randomized conjoint analysis. The attribute levels were assigned randomly, and ordinary least squares (OLS) was used to estimate the AMCE of each attribute as a coefficient based on a linear regression of the indicator of choice over the set of dummy variables for the attributes and levels. The model is as follows:

$$\mathbf{y_{itj}} = \boldsymbol{\beta_0} + \sum_{l=1}^{L} \sum_{d=2}^{Dl} \boldsymbol{\beta_{ld}} \times \mathbf{a_{itjld}} + \mathbf{u_{itj}}$$

where the possible outcome of individual *i* in trial *t* of policy *j* is defined by y_{itj}, *l* stands for several attributes, and D_l indicates the number of levels of each attribute *l*. β_{ld} is the coefficient of each component to be estimated, a_{itjld} is a dummy variable for the dth level of policy *j* in task *t* of respondent *i*, and $u_{itj} \in \{0,1\}$ is an error term. In the internal choice probability estimation, y_{itj}= 1 if the preference rank of policy *j* is higher than its alternative policy and 0 if the rank is smaller. Similarly, in the estimation of the external choice probability, y_{itj} = 1 if the preference rank of policy *j* is higher than the status quo.

3. Results

During the survey, some general information about the respondents was collected and analyzed. The gender balance was nearly equal: 49.06% were female, and the rest were male. In terms of age, almost 69% of the respondents belonged to the 17–40 years category, which represents the young adult population in Nepal. The highest proportion of our respondents (42.36%) had a university degree, followed by secondary education (34.05%), basic education (15%), and no literacy (8.56%). Similarly, 43.16% used public transport to get to work, 20.11% for school, 15.28% for grocery shopping, and 7.24% for leisure. In terms of vehicle ownership, 64% of the respondents had no vehicle, 16.62% had a motorbike, 11.8% had a car, and 2.68% had a bicycle. The respondents' current travel mode was split between bus (47.45%), microbus (23.59%), motorbike (12.33%), minibus (9.12%), and tempo (auto-rickshaw) (3.75%).

The average marginal component effect (AMCE) is the causal quantity of estimation using a pooled sample for external choice probabilities and internal choice probabilities. It reflects the probability that profile (A) or (B) will be chosen by the respondent (Hainmueller et al., 2014). This survey also includes the status quo (C), which allows us to analyze a hypothetical proposal for improved public transport features based on the current Kathmandu public transport service. An airplane dot plot is used to show the corresponding coefficient on the X-axis, with the 95% confidence interval shown using horizontal bars, and the vertical axis shows the proposed attributes and their levels.

First, as a baseline, the most commonly used values for public transport of each attribute level *(written in italics and bold letters in Table 1)* were used to compare Choice (A) and Choice (B), with the status quo included to analyze the external probability. In the second part, we analyzed the internal probability using a baseline the same as the external probability, and we compared the proposed hypothetical policies Choice (A) and Choice (B) only, without the status quo.

The probability of external choice shows that commuters accept the new and improved characteristics of the public transport service compared to the current situation (status quo). The constant term of the regression was 0.7288, which means that 73% of the respondents chose profile (A) or (B) rather than (C). The estimated average marginal treatment effect (AMCE) on external choice probability found a significant impact for all attributes. The results show that the attributes with the highest impact on the probability of choosing a hypothetical policy were one-way starting fare and mode of transport.

The first attribute, modes of transport, had five levels, with the baseline set to bus. However, the second level (microbus) and the third level (taxi) were not significant. The fourth level (motorbike) was negatively significant. Fourteen percent of the respondents did not like to use a motorbike as a form of transport. The fifth level (MRT) was preferred over the baseline by 20%. This shows that commuters are eager to move from the current situation to a new public transport system. The second attribute, waiting time, had three levels: 5 minutes, 15 minutes, and 30 minutes. When we set 15 minutes as the baseline, a waiting time of 5 minutes had a positive impact probability of 12%, and a 30-minute waiting time had a negative influence of 12% when implemented. For the commute time (per km) attribute, 5 to 15 minutes was set as a baseline, and the level of less than 5 minutes had a positive impact of 12%, while the level of more than 15 minutes had a negative effect of 12%, which means respondents do not like an increase in commute. The attribute one-way starting fare was the most influential key attribute in terms of external probability. If the new one-way starting fare was set to NRs 60, the

probability of respondents taking the new public transport was negatively affected by -54%, by -45% when set to NRs 45, and by -28% when set to NRs 30, which is useful information for developing a new policy. The fifth and last attribute, fare payment method, had a significant effect. It comprised two levels: e-payment and cash. When we set cash as the baseline, the choice of e-payment had a positive impact of 3%, which means that respondents like to use e-payment (Fig. 2*)*.

Internal choice probability reveals respondents' preference between the two proposed public transport improvement packages, package (A) and package (B). They preferred the improved service, which includes a mass transit system, less waiting, shorter commute times, and a lower fare per km. Although it improves the service, they do not care about the fare payment method *(*Fig. 3*)*. The first attribute, mode of transport, had five levels, with the baseline set to bus. However, the second level (microbus) and the third level (taxi) were not significant. The fourth level (motorbike) was negatively significant, and 12% of the respondents did not like to use a motorbike for public transport. The fifth level (MRT) was preferred by 14% over the baseline. The second attribute, waiting time, had three levels: 5 minutes, 15 minutes, and 30 minutes.

When we set 15 minutes as a baseline, the 5-minute waiting time increased the positive probability by 13%, and the 30-minute level had a negative influence of 14%. For the attribute commute time (per km), when the level of 5 to 15 minutes was set as a baseline, the level of less than 5 minutes had a positive impact of 9%, and the level of more than 15 minutes had a negative impact of 12%. The one-way starting fare attribute was highly negatively significant, with a level of NRs 30 affecting the result by -20%, NRs 45 by -34%, and NRs 60 by -48%, indicating a significant influence on the negative choice probability estimated at the level of NRs 14.

For the probability of internal choice, we proposed two hypothetical policies on improved public transport service based on the bundles of attributes and estimated the preference of respondents who answered the question, *"Which is the most influential among the proposed policies?"* For the external choice probability, we included the status quo as an answer to the question, *"Do we need a new proposed transport policy?"* The result of the estimation shows that the preference trends are similar except for the fifth attribute; for the probability of internal choice, respondents did not care about the payment method. The comparative results of external and internal choice probability are presented in *Table 2*.

4. Discussion

In the context of switching to a new public transport system, several attributes (mass rapid transit as the mode of transport, less waiting time, less commute time per km, and e-payment) had a clear influence on the approval of an improved system. However, commuters had negative feelings toward the use of motorbikes as public transport as well as toward increases in fare, waiting time, and commute time per km, and they did not prefer microbuses and taxis.

Due to the unreliable and inefficient nature of the public transport service, the use of two-wheelers, in particular motorbikes and scooters, has increased rapidly in the Kathmandu Valley, presenting a major challenge for maintaining sustainable urban mobility. This result confirms the JICA study, which stated: "At present, about 90% of buses in the Kathmandu Valley are low occupancy vehicles, i.e., micro/minibuses. Smaller buses should be replaced by larger ones to operate the public transport system efficiently. The current transport network system of Kathmandu Valley is dependent on private vehicles and will not meet future demand; the introduction

of a new public transport system, such as AGT or BRT, is recommended" (JICA, 2017 p. 114). Shrestha, Oanh, Xu, and Rupakheti (2013) claimed that low-speed buses and motorbikes were the main sources of emissions in the Kathmandu Valley. Moreover, our results support their finding that commuters are in favor of mass rapid transit.

From this study, we found that MRT, low fares, less waiting time, less commute time, and cashless payment methods are influential attributes promoting switching to public transport for nearly all commuters of different backgrounds. However, Jain et al. (2013) found that safety is the most important criterion for encouraging urban commuters to shift from private vehicles to public transit, followed by reliability, cost, and comfort. Chen and Chao (2011) concluded that the habitual behavior of private vehicle users somewhat hindered individual intent to switch from private vehicle to mass rapid transit. In this study, individual characteristics, such as gender, vehicle ownership, sense of security of the current public transport system, and level of education, may affect modal shifts from private to mass transit differently. Ashalatha, Manju, and Zacharia (2013), in their study of the mode choice behavior of commuters in the city of Thiruvananthapuram, India, found that the preference for a car increases with increasing age, while the preference for two-wheelers decreases. Therefore, the switch from private vehicles to public transit depends upon time per distance and cost per distance. The results of a subsample analysis using the background information in this study supported their findings. In a case study of the city of Kalamaria, Greece, commuters placed importance on the attribute of comfort, followed by fare, information provision, and accessibility to a transit network (Tyrinopoulos & Antoniou, 2013). However, commuters gave comfort (i.e., MRT and negative views of motorbikes) and fare almost equal preference in Kathmandu. Likewise, IBN (2017) proposed investments in mass transit system projects, i.e., MRT, LRT, BRT, flyovers, and tunnelway systems, for the sustainable mobility of the Kathmandu Valley. This study empirically outlined the effective implementation of proposed mass rapid transit projects in Kathmandu Valley. However, Pathao and Tootle have been using motorbikes and scooters as public transport in Kathmandu since 2018. Legal provisions do not allow the use of two-wheelers as a public transportation service in Nepal. According to the Motor Vehicles and Transport Management Act of 1993, commercial vehicles must obtain a permit to operate and must have registered their public transport service in the DoTM; however, Pathao and Tootle have been operating two-wheelers without registering with the transport service, which is illegal (OAGNEP, 2020 p. 304). Motorbikes are the main cause of traffic congestion, air pollution, and road accidents (Shrestha et al., 2013). The results of this study confirm that respondents are not in favor of two-wheelers in the city of Kathmandu.

The improvement of the current public transport system is the most important and urgent agenda item for the overall development of the country. Although the government has made efforts to improve the public transport service sector in Kathmandu, these efforts have not been effective. The weak capacity and authority of the regulatory body, scarce resources, weak policy enforcement, and the low participation of stakeholders are the main problems for sustainable implementation.

This empirical study indicates that commuters are in favor of a new, improved public transport system. While formulating a new policy, it would be best to focus on the introduction of MRT with the e-payment method for public transport services, and to consider low fares or other schemes, such as monthly or yearly ticketing or family packages, to motivate commuters to embrace the new system. Public transport should run on a timely basis, which would enhance commuters' trust in addition to their comfort and the price. This study also envisages the effective implementation of the BRT project on the Ring Road in Kathmandu, proposed by the IBN, and recommends applying the minimum fare with the cashless payment method. Referring to the subsample

analysis, commuters whose permanent residence is outside of Kathmandu Valley also preferred MRT, which shows that MRT is the best means of transport for urban mobility in other large cities as well.

5. Conclusion

This study has focused on examining commuters' preferences for improved public transport services in Kathmandu Valley. A choice-based conjoint experiment was conducted that included five attributes and 17 levels, all of which may affect commuter preference in terms of switching to public transport. All five attributes had the expected significant impact on the intention to switch to enhanced public transport. The constant term for the probability of external choice is 0.728, which indicates that the percentage of people who will support the new and improved public transport service is 73%. The most significant attributes are one-way fare per km and the mode of transport. Commuters are in favor of a modal shift to mass rapid transport and against motorbikes. They are strongly against increases in the current fare, waiting time, and commute time. However, they prefer to switch from cash to e-payment. This case study has focused on an area with high traffic congestion and its suburbs. The results of this study will support transport planners in formulating and implementing an effective transport policy that takes people's preferences into account.

Declarations

Availability of data and materials

The dataset used and analyzed during the current study is available from the corresponding author on reasonable request.

Competing interests

The authors declare no conflict of interest.

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Authors' contributions

Execution of experimental work and preparation, T.R.A.; Conceptualization, T.R.A. and M.I.; programing, S.K. and M.I.; software, T.R.A. and M.I.; writing—original draft preparation, T.R.A.; writing—review and editing, M.I.; supervision, M. I. All authors have read and agreed to the published version of the manuscript.

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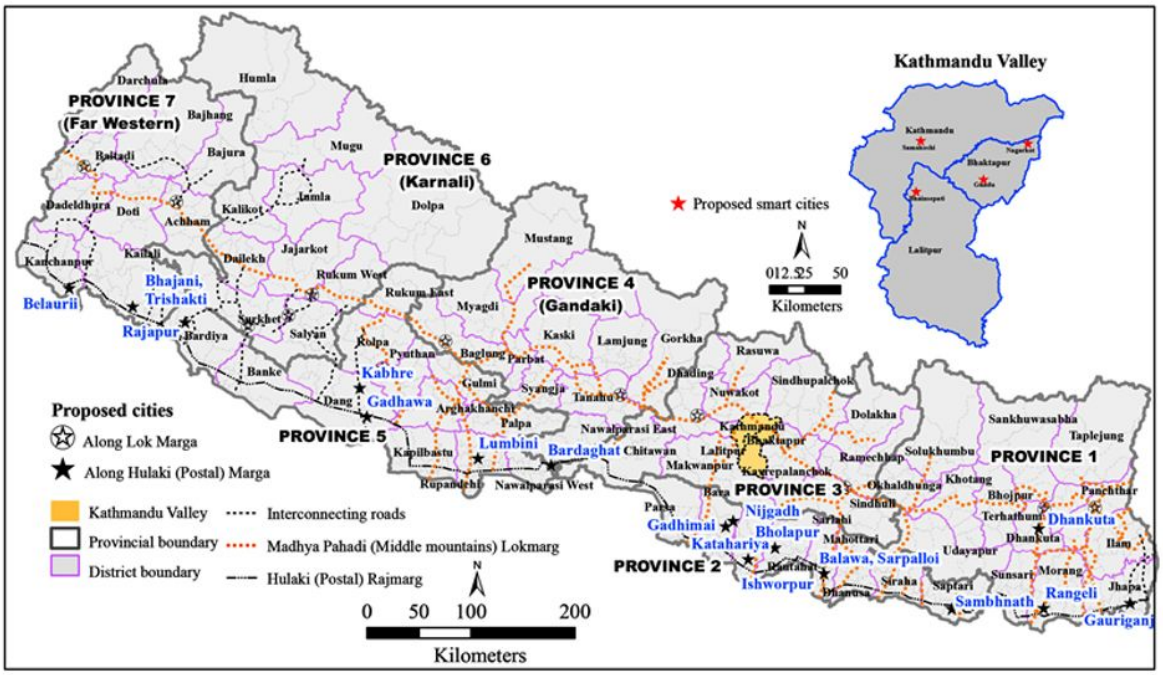
Tables

Table 1-2 are available in the Supplementary Files section.

Figures



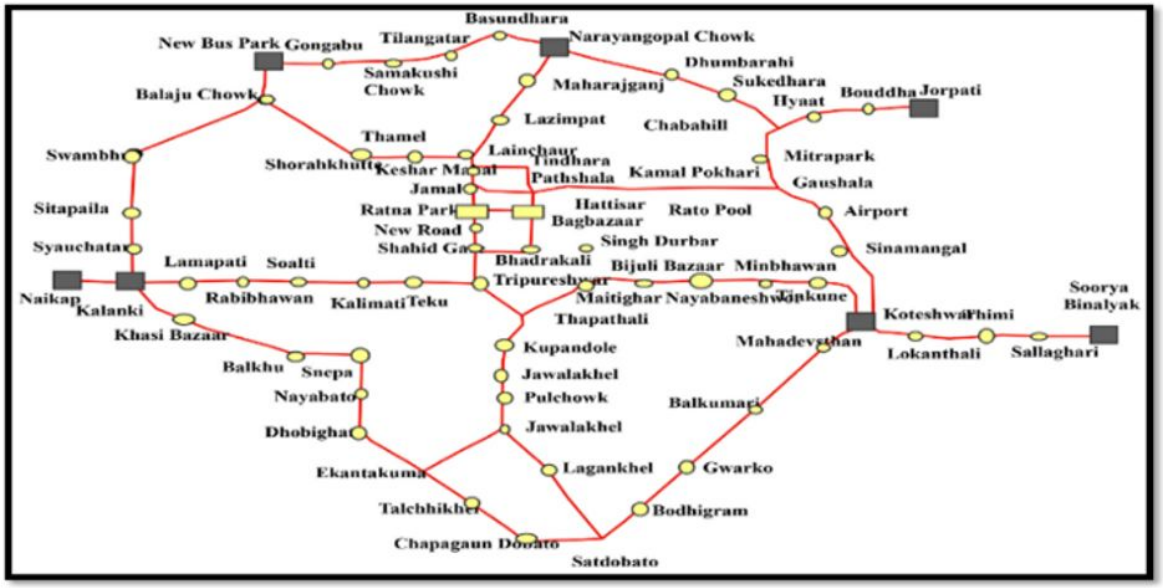


Figure 1

Kathmandu Valley and Ring Road covered area

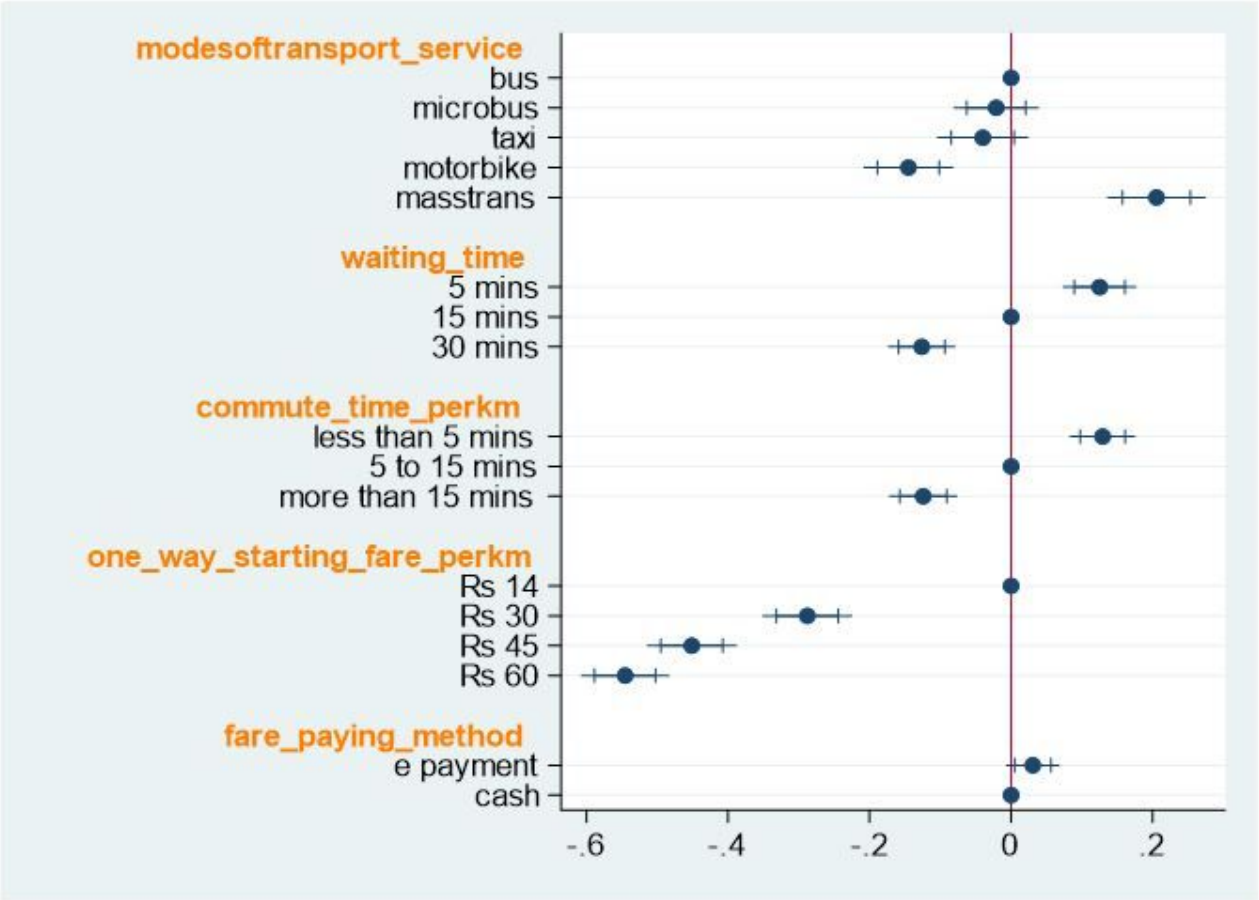


Figure 2

Average Causal Effect on the External Choice Probability

Constant = 0.728 Note: Cluster standard error is estimated at the respondent level, and the horizontal bar is adjusted within a 95% confidence interval.

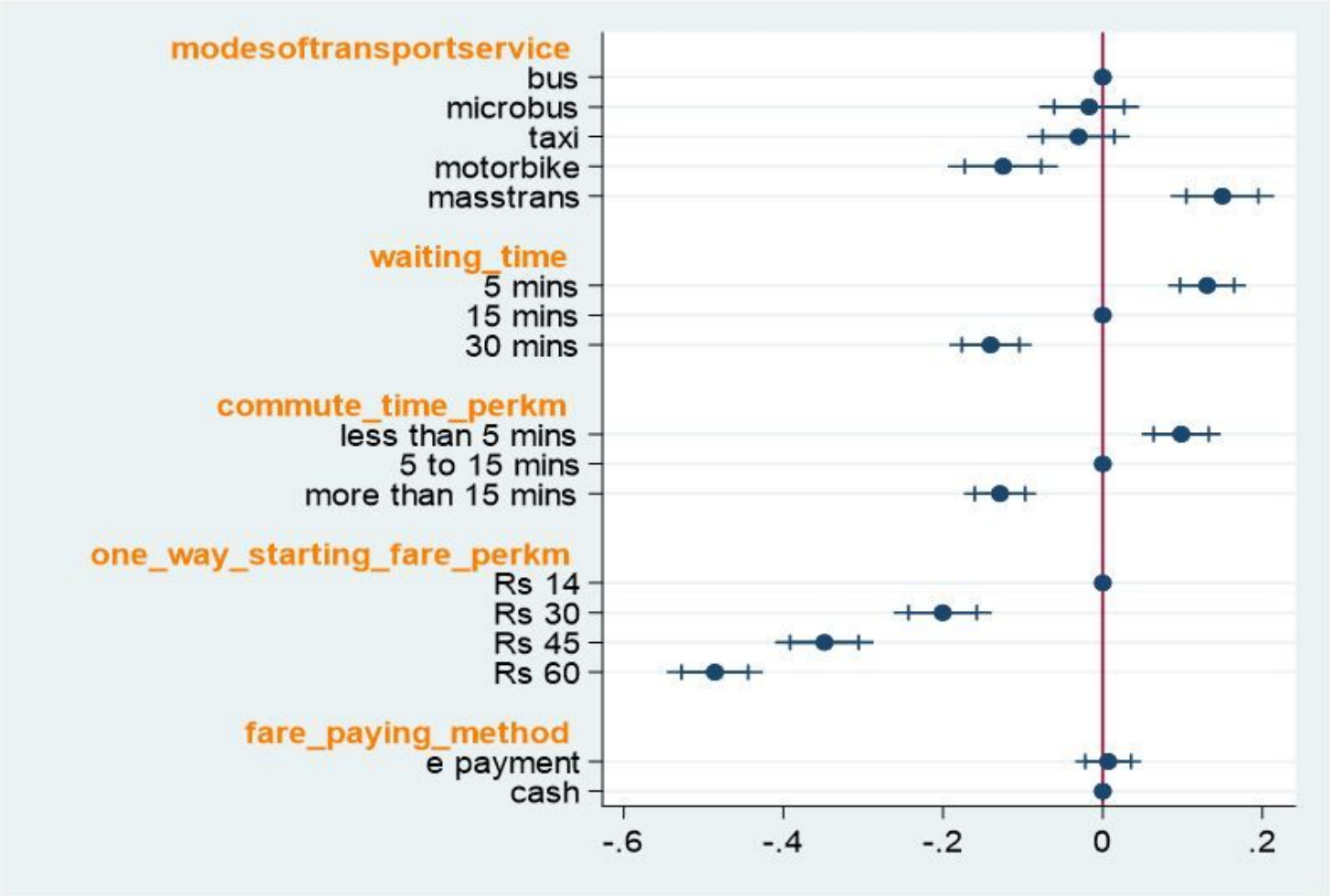


Figure 3

Average Causal Effect on the Internal Choice Probability

Constant = 0.770 Note: Cluster standard error is estimated at the respondent level, and the horizontal bar is adjusted within a 95% confidence interval.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Tables.docx